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by Michael A. Taras

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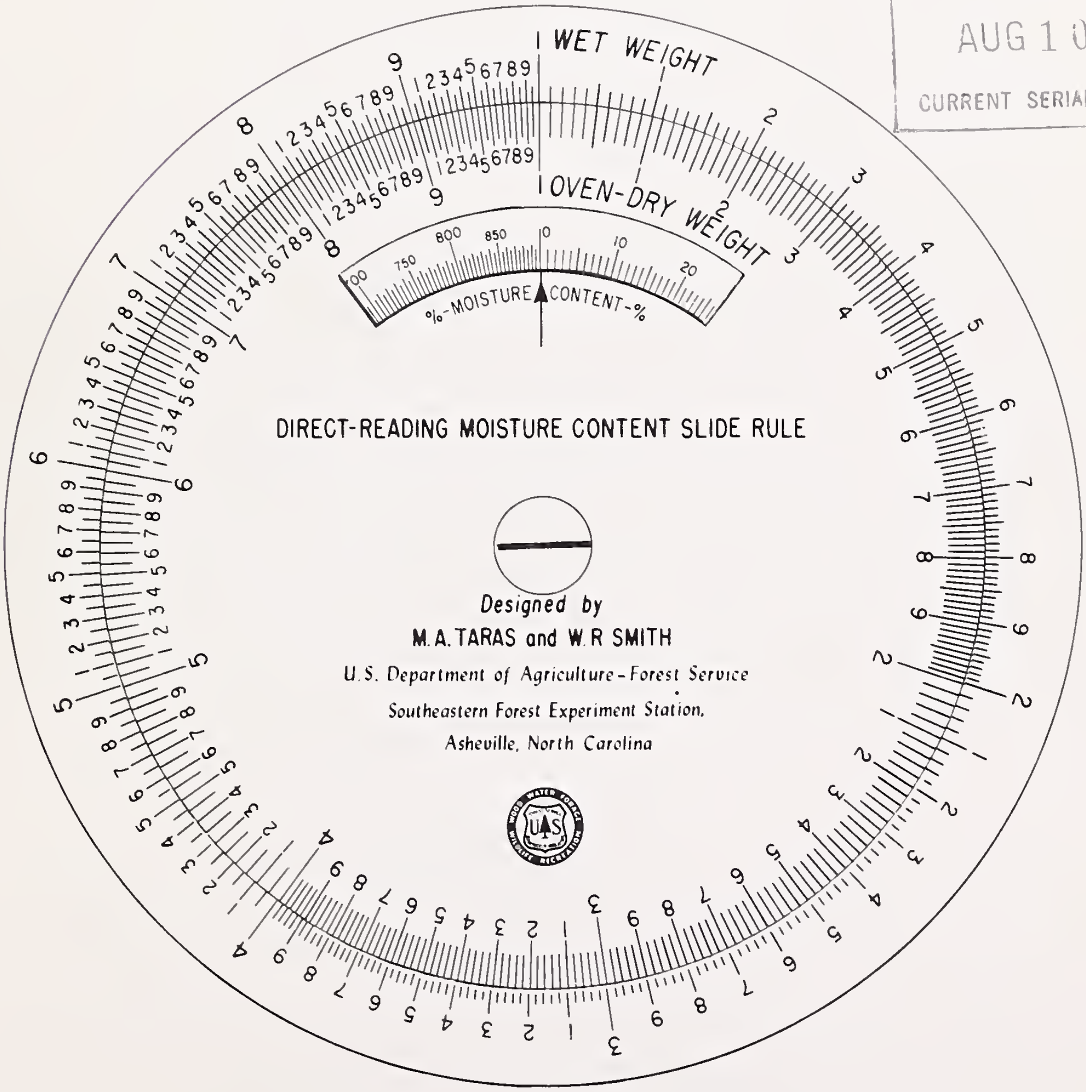
WET WEIGHT
OVEN-DRY WEIGHT
%-MOISTURE CONTENT-%
DIRECT-READING MOISTURE CONTENT SLIDE RULE
Designed by
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Circular Slide Rule
for
Calculating Wood Moisture Content

by

Michael A. Taras

Moisture content is perhaps the most frequently determined and one of the most important physical properties of wood. Dry kiln operators make countless moisture determinations every day in order to establish drying schedules that will produce quality stock for the wood-using industries.

The moisture content of solid wood is expressed as a percentage of its ovendry weight.[1] Because ovendry weight is used as a basis for calculating moisture content, the values obtained can be in excess of 100 percent. It is relatively easy to calculate moisture content after the green weight and ovendry weight have been determined; it is merely a matter of subtraction and long division. Shortcut methods have been developed for use on slide rules and calculating machines, but such instruments frequently are not available to lumberyard foremen and dry kiln operators.

The direct-reading moisture content circular slide rule was developed to simplify calculations, reduce the time of calculation, and help improve accuracy by reducing the number of mathematical steps which so frequently are the cause of errors in any computation. In the back of this publication is a working model of this slide rule. The respective parts can be cut out and put together for use. It is extremely important, in assembling the slide rule, that the center points of the disks be aligned perfectly. If they are not, the rule will give erroneous results. A standard $\frac{3}{16}$-inch Chicago center post can be obtained at any stationery store and it will fit snugly into a punched out circle at the center of the disk.

Individuals who are familiar with the operation of a conventional slide rule and know the scale calibrations can use this circular slide rule with very little instruction. Knowing the green or wet weight and the ovendry weight of a wood sample, one has only to match up the green weight on the outer scale with the ovendry weight on the inner scale and read the moisture content in percent direct from the scale that appears in the cutout window on the inner dial. Instructions for those not familiar with a slide rule are in the text which follows.

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[1] Exceptions to this exist in some industries. The pulp and paper industry express moisture content based on the percentage of the green weight, and in this case the moisture content percent could never exceed 100 percent.

USING THE CIRCULAR SLIDE RULE

A few rather simple rules will make it possible for anyone to operate the Direct-Reading Moisture Content Slide Rule. Although the inner dial, marked "Ovendry weight," is smaller than the outer dial, "Wet weight," the two are identical in markings. The following explanation applies to both dials.

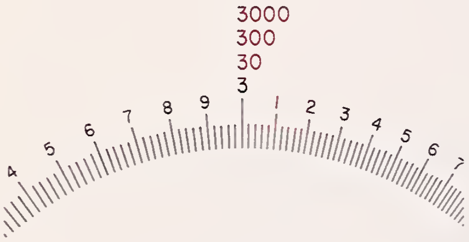

Figure 1

Around the outer edge of the dial are large numbers from 1 to 9. Depending upon the system of weights you are working with, these numbers can be either pounds or grams. Any of the large numbers can stand for a single unit, such as 1 pound or 1 gram; zeros may be added to raise the value in multiples of 10, 100, or 1,000. For example, the large 3 can represent 3, 30, 300, or even 3,000 grams (fig. 1).

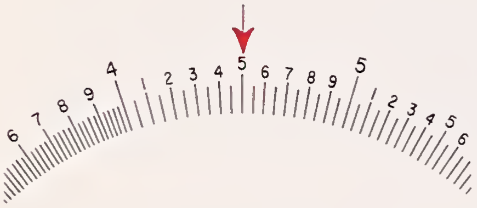

Figure 2

The small numbers, running from 1 to 9, between each of the large numbers are used for two-digit entries. For example, if you want to locate 45 grams on the rule, first locate large number 4, then the small number 5 that is halfway between large 4 and large 5. Again, as with the large numbers, this point can also represent 4.5, 45, 450, or 4,500 grams or pounds (fig. 2).

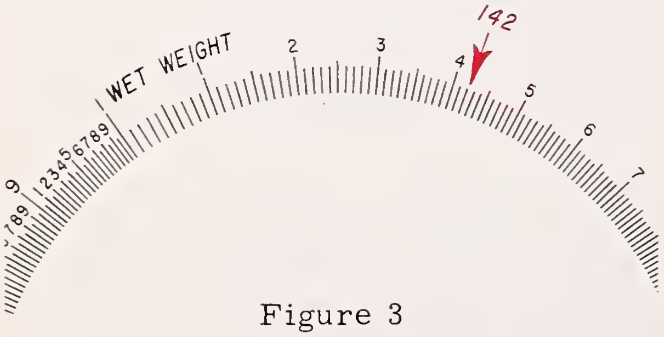

Figure 3

There are still finer divisions on the circular slide rule, and although they are not numbered, it is quite easy to know their value. For example, between large number 1 and large number 2 each smaller division has ten unnumbered lines; therefore, each fine line has a value of 1, and represents the third digit of a three-digit number. Figure 3 shows the three-digit number 142. Three-digit values can be read with reasonable accuracy over the entire rule, even though the third digit must be estimated in the area of the slide rule beyond large number 2.

Between large number 2 and large number 4, the unnumbered lines have a value of 2. For example, if you had the value 252 you first locate large 2, then the small 5 between large 2 and 3, and then locate the first unmarked division following the small number 5. This small unmarked division represents the last 2 in the value 252 (fig. 4). If the last number of a three-digit value is odd, such as 213, the process for locating the first two digits is the same as before; however, when the last digit is odd (3), you must estimate the midpoint between the first and second unmarked division. Figure 5 shows the location of the value 213.

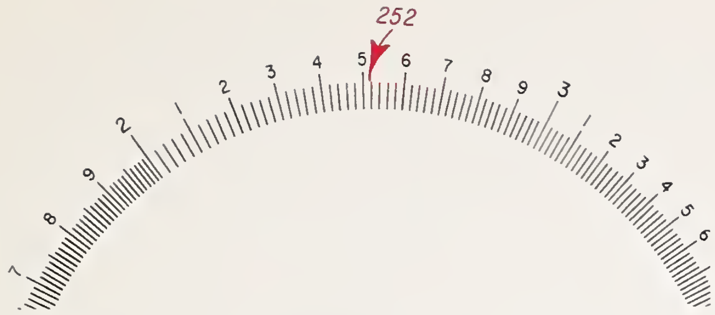

Figure 4

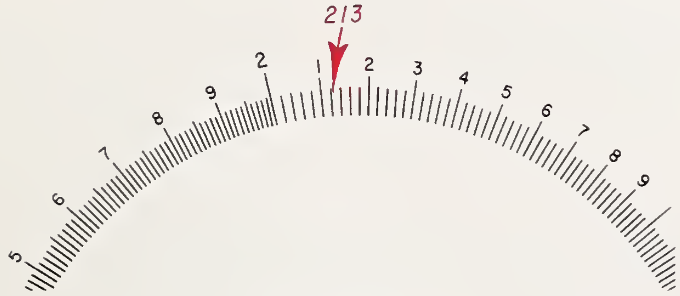

Figure 5

Beyond large 4 each unnumbered line has a value of 5. Values from 1 to 4 and 6 to 9 between these unmarked divisions in this part of the slide rule must be estimated. Figure 6 shows the location of the three-digit value 573.

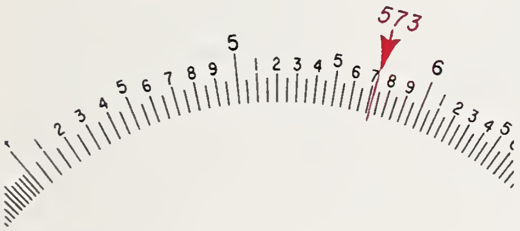

Figure 6

If you remember the following you should have no difficulty using the rule:

1. If the value only has one digit in it, such as 8, find the large number 8 on the rule.
2. If it has two digits, such as 45, first find the large number 4, then the small 5 which follows the large 4.
3. If it has three digits, as 155, first locate the large number 1, then the small number 5, and then the unmarked subdivision that represents 5.
4. If it has four digits, it will be reasonably accurate between large 1 and 2 but not beyond. The same procedure is followed as above; when you come to the fourth digit you must estimate between the finest divisions.

CALCULATING MOISTURE CONTENT

The basic formula used to calculate moisture content is as follows:

$$\frac{Wg - Wd}{Wd} \times 100 = \text{moisture content (percent)}$$

where

Wg = weight green

Wd = weight ovendry

For example, a green board weighs 5 pounds. It is put in an oven and dried until it no longer loses weight, at which time it weighs 2 pounds. Then:

$$\frac{5 - 2}{2} \times 100 = \text{moisture content (percent)}$$

$$\frac{3}{2} \times 100 = \text{M. C.}$$

$$1.5 \times 100 = \text{M. C.}$$

150 percent = moisture content

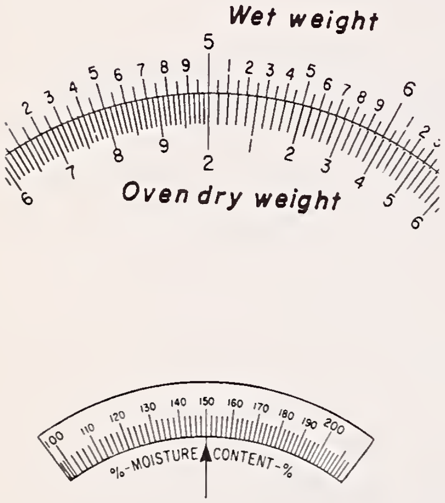

Figure 7

In using the direct-reading moisture content slide rule the foregoing computations have been reduced to the simple matter of finding the wet weight, 5, on the outer scale and placing directly beneath it the ovendry weight, 2, read on the inner scale. The percent moisture content, 150, will appear opposite the arrow in the cutout window. Figure 7 shows the settings on the slide rule for this computation.

The moisture content scale, like the wet and ovendry scales, has a variety of divisions. From 0 to 100 each fine division represents 1 percent moisture content; fractions of 1 percent must be estimated. Between 100 and 300 each small division represents 2 percent moisture content and between 400 and 899 each small division represents 5 percent.

Listed below are a series of practice problems, covering a variety of weights, that will be helpful in learning to read the slide rule scales for the first time. The answers to the problems are in the back of this booklet.

Number	Green Weight	Ovendry Weight	Percent Moisture Content
1	8 gms.	2 gms.	______
2	35 gms.	22 gms.	______
3	101 gms.	39 gms.	______
4	1800 gms.	955 gms.	______
5	16.4 gms.	10.2 gms.	______

CALCULATION OF OVENDRY WEIGHT

In addition to calculating the moisture content of a wood moisture section, kiln operators will also find this slide rule useful in determining the calculated ovendry weight of the kiln sample boards that are used as indicators of the moisture content of a kiln charge of lumber. To determine the calculated ovendry weight of kiln sample boards, the slide rule is operated in reverse manner to that used for determining the moisture content. In this calculation a moisture content and the green weight of the sample board must be known. The moisture content (percent) is located at the moisture content indicator in the cutout window. The green or wet weight of the sample board is then located on the outer scale and the calculated ovendry weight is read from the inner dial opposite the wet weight. For example, if the moisture content of the sample moisture sections is 60 percent and the green weight of the sample board is 21.2 pounds, the calculated ovendry weight is 13.2 pounds. This value is used throughout the kiln run to determine the moisture content of the sample board as drying progresses.

DETERMINATION OF EQUILIBRIUM MOISTURE CONTENT

If wood is exposed to a given temperature and relative humidity, it will, in time, reach a state of equilibrium with the atmospheric conditions: water will neither move into nor out of the wood. The moisture content attained by the wood under these conditions, at the point of balance, is known as the equilibrium moisture content or EMC of the wood. A knowledge of the atmospheric conditions that will give a certain EMC is essential if kiln operators are to dry wood down to a given moisture content.

Several years ago the Forest Products Laboratory published a table giving the EMC of wood for given atmospheric conditions.[2] This EMC table has been put into a slide rule form and is printed on the back side of the direct reading moisture content slide rule. In order to use this rule all you must know is the dry bulb temperature and the wet bulb temperature; EMC values have been rounded off to the nearest one percent.

The EMC slide rule is constructed to cover a span of dry bulb temperatures from 70° to 200° F. From 70° to 130° F. the column is divided in 5-degree intervals, and from 130° to 200° F. in 10-degree intervals. Above and to the right of the column of dry bulb temperature values is a small cutout window, where the wet bulb depression value appears. The wet bulb depression is the difference between the dry bulb and the wet bulb temperature. Wet bulb depression values are listed by 1 degree up to 30° F. depression; by 2 degrees from 30° to 40° F. and by 5 degrees between 40° and 50° F.

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[2] Smith, Harvey H. Relative humidity and equilibrium moisture content graphs and tables for use in kiln drying lumber. U. S. Forest Serv. Forest Prod. Lab. Rpt. 1651, 5 pp., illus. 1956.

Operation of the EMC slide rule is simple. The dial on the slide rule is turned until the desired wet bulb depression appears in the small window near the outer margin of the disk. The desired dry bulb temperature is selected from the column of values listed opposite the long cutout window, and the equilibrium moisture content is read in the cutout window opposite the dry bulb temperature selected.

Answers to Problem on page 4.

Number	Answer
1	300
2	59
3	159
4	88
5	60.7

CONSTRUCTING THE SLIDE RULE

Step 1: Carefully cut out the four disks on dotted lines.

Step 2: Following dotted lines, cut out windows on disks A and B.

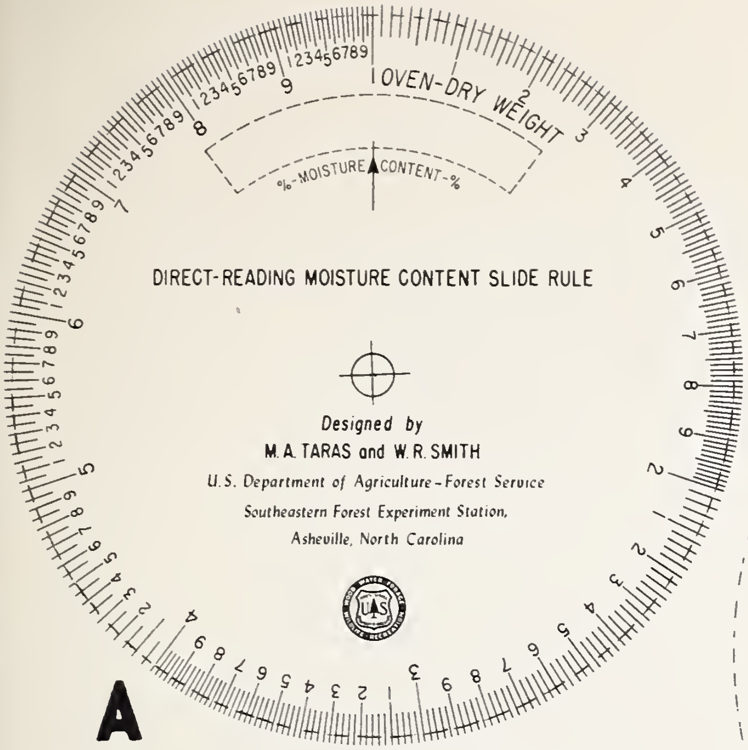
Step 3: Cut out center post holes on each disk.

Step 4: Glue the back of disk C to the back of disk D.

Step 5: Place disk A over disk D.

Step 6: Place disk B over disk C.

Step 7: Insert 3/16-inch Chicago center post.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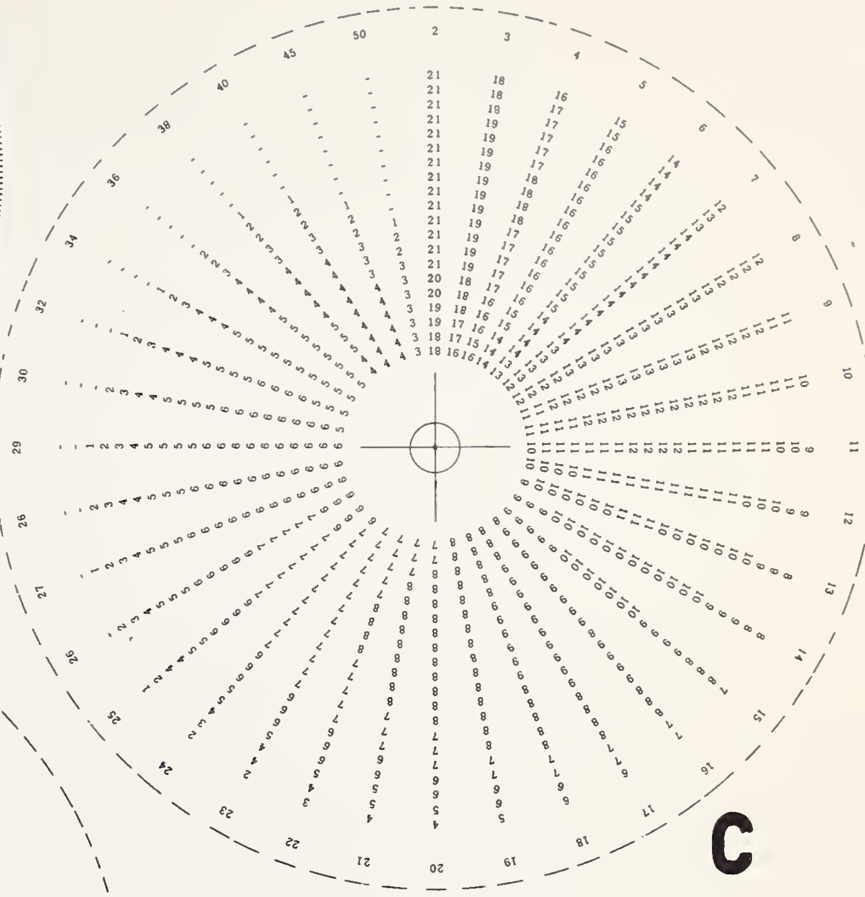
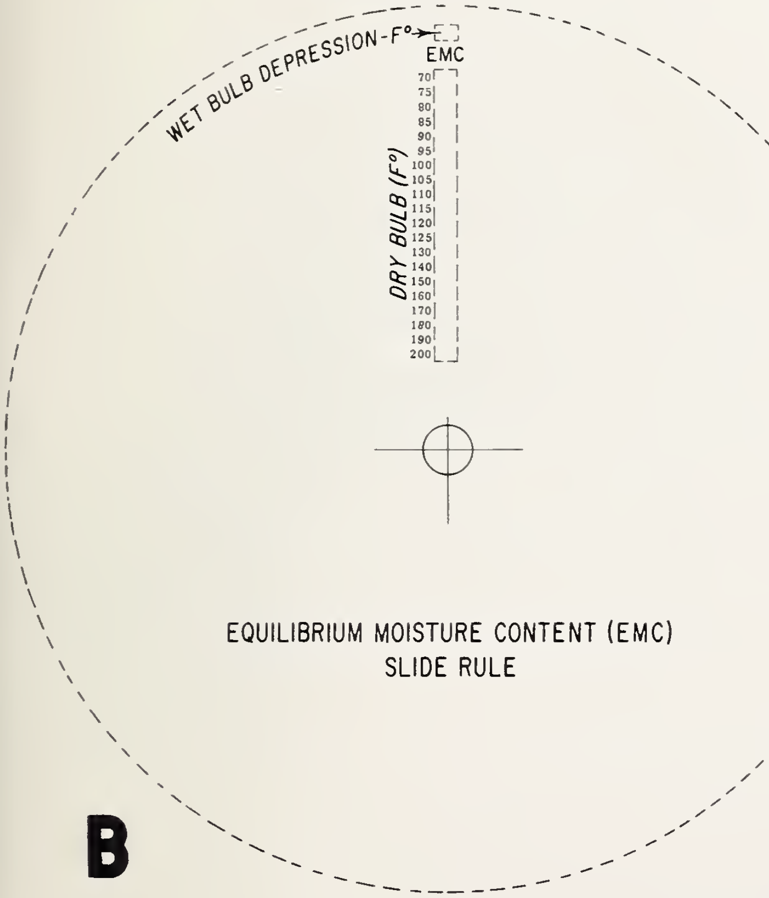
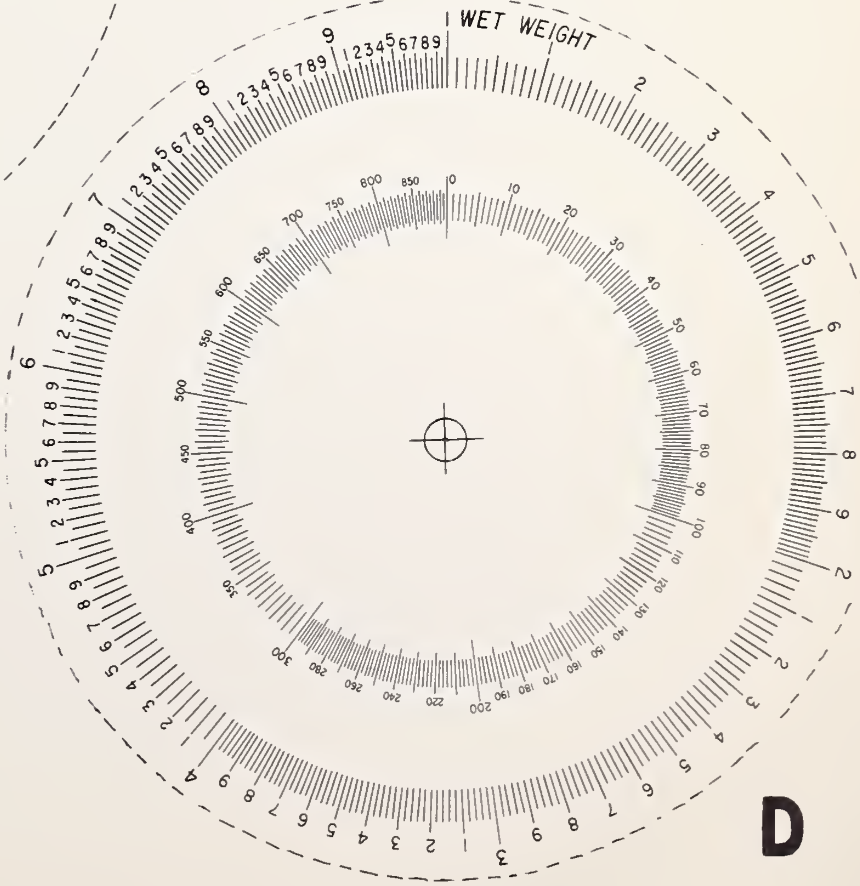
A



C


WET BULB DEPRESSION-F°
EMC
DRY BULB (F°)
EQUILIBRIUM MOISTURE CONTENT (EMC)
SLIDE RULE

B


WET WEIGHT

D